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Morphometric Analyses with 15 Subspecies of Striped Field Mouse, *Apodemus agrarius* Pallas (Mammalia, Rodentia) from Eurasia

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ABSTRACT

Thirty one morphometric characters of specimens in 15 subspecies of striped field mouse (*Apodemus agrarius* Pallas) from Eurasia were analyzed to clarify taxonomic status of these subspecies. Five major subgroups in *A. agrarius* were revealed: I, a largest-size form, specimens from two southern islands in Korea, subspecies *chejuensis*; II, a large-size form, specimens from other six localities in Korea, subspecies *coreae* and *pallescens*; III, the other large-size form, specimens from Astrachan in western Russia, subspecies *volgensis*; IV, a medium-size form, specimens from 16 localities in eastern Asia (North Korea, China, and eastern Russia), subspecies *coreae, manchuricus, pallidior, ningpoensis,* and *insulaemus;* V, a small-size form, specimens from 16 localities in western Asia and Europe (Kazakhstan, Russia, Lithuania, and Ukraine), subspecies *tianschanicus, ognevi, agrarius, septentrionalis, nikolski, caucasicus,* and *karelicus.* From this morphometric analyses, the followings are concluded: subspecies *chejuensis* is a largest-size form, as noted by Johnson and Jones (1955): subspecies *pallescens* is the synonym of subspecies *agrarius,* as suggested by Koh (1986): subspecies *coreae* from Korea is a large-size form and is distinct from other 12 subspecies in Eurasia: the eastern form of subspecies *ningpoensis* by Corbet (1978) is a medium-size form of subspecies *manchuricus, pallidior, ningpoensis,* and *insulaemus* from eastern Asia (China and eastern Russia), and it includes North Korean specimens: a small-size

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form from western Asia and Europe (subspecies *tianschanicus, ognevi, agrarius, septentrionalis, nikolski, caucasicus,* and *karelicus*) is the western form of subspecies *agrarius* by Corbet (1978): the other large-size form of subspecies *volgensis* from western Russia is a distinct subspecies, which differs from the western subspecies *agrarius*. Therefore, it is concluded that 15 subspecies of *A. agrarius* can be classified into five subspecies (*chejuensis, coreae, ningpoensis, agrarius,* and *volgensis*), although it is necessary to measure and analyze morphometric characters of specimens of other seven subspecies (*albostriatus, maculatus, rubens, kahmanni, henrici, gloveri,* and *harti*) for the complete reclassification of this species.

Key words: Taxonomy, Morphometry, *Apodemus agrarius*, 15 subspecies, Eurasia

INTRODUCTION

Striped field mouse, *Apodemus agrarius* Pallas 1771, is widely distributed in Eurasia from Germany to Korean peninsula, and most of subspecies were designated on the basis of slight differences in pelage colour and/or body size (Corbet, 1978). Thomas (1908) distinguished four subspecies of *Apodemus agrarius* in China and Korea mainly based on dorsal stripe, and Corbet (1978) summarized 24 nominal subspecies into three subspecies, *agrarius*, a western subspecies including 12 named subspecies from western Asia and Europe in Eurasia (*tianschanicus, ognevi, septentrionalis, nikolski, caucasicus, karelicus,* and *volgensis* and other five named subspecies of *albostriatus, henrici, kahmanni, maculatus,* and *rubens*); *ningpoensis*, an eastern subspecies from eastern Asia in Eurasia including eight named subspecies (*coreae*, *pallescence*, and *chejuensis* in Korea, *manchuricus, pallidior,* and *insulaemus* in China, and other two named subspecies of *gloveri* and *harti*); and *chevrieri*, a southern Chinese subspecies *including* one named subspecies of *fergussoni*. Wang (1985) concluded that subspecies *chevrieri* is a distinct species, and Kobayashi (1985) noted that there are many problems in the systematics of the genus *Apodemus* and that it is necessary to reexamine the subspecies classification of striped field mouse, *Apodemus agrarius*, in Eurasia.

The methods of numerical taxonomy based on equal weighting and overall similarity seemed to have potential for the resolution of taxonomic problems at the infraspecific level (Flake and Turner, 1968). In morphometric analyses with samples of three subspecies of *Apodemus agrarius* from ten localities of Korea, it was revealed that *A. a. pallescens* is the synonym of *A. a. coreae* and that *A. a. chejuensis* is larger than *A. a. coreae* (Koh, 1986). In the analysis with morphometric characters of six subspecies of striped field mouse from China and Korea (Koh, *et al.*, 1997), three subgroups were revealed: *chejuensis* (a large-size form), *coreae* (a medium-size form), and other four subspecies of *manchuricus, ningpoensis, pallidior,* and *insulaemus* (a small-size form).

The objective of this paper is to analyze morphometric characters of 15 subspecies of *Apodemus agrarius* from most of the distribution area of Eurasia to reexamine taxonomic status of

Table 1. Specimens of 15 subspecies of striped field mice, *Apodemus agrarius* from Eurasia.

Subspecies	Locality	No. of Samples	OTU
chejuensis	Chejudo Island, Korea	47	1
〃	Wando Island, Korea	25	2
pallescens	Jindo Island, Korea	20	3
〃	Kunsan, Korea	28	4
coreae	Mt. Chirisan, Korea	21	5
〃	Cheongju, Korea	85	6
〃	Mt. Weolaksan, Korea	35	7
〃	Mt. Taebaeksan, Korea	14	8
〃	Haeju, North Korea	19	9
〃	Mt. Kumkangsan, North Korea	25	10
〃	Sineuiju, North Korea	21	11
〃	Mt. Myohyangsan, North Korea	27	12
manchuricus	Vladivostok, Russia	44	13
〃	Ternej, Russia	36	14
〃	Jirin, China	47	15
〃	Yichun, China	17	16
pallidior	Sandong, China	29	17
〃	Hopeh, China	19	18
ningpoensis	Anhui, China	10	19
pallidior	n. Jiangsu, China	11	20
ningpoensis	Kiangsi, China	14	21
〃	Hupeh, China	26	22
〃	Sichuan, China	22	23
insulaemus	Taiwan	8	24
ognevi	Novosobirsk, Russia	12	25
tianschanicus	Minusinsk, Russia	27	26
〃	Bijsk, Russia	17	27
〃	Ajagra, Kazakstan	24	28
〃	Alma-Ata, Kazakhstan	19	29
caucasicus	Nalchik, Russia	49	30
volgensis	Astrachan, Russia	18	31
agrarius	Troick, Russia	7	32
〃	Birsk, Russia	18	33
〃	Kazan, Russia	24	34
〃	Vinnica, Ukraine	32	35
nikolski	Kursk, Russia	33	36
〃	Bobrov, Russia	38	37
septentrionalis	Rajan, Russia	17	38
〃	Komakovo, Russia	64	39
karelicus	Petersburg, Russia	15	40
〃	Trakai, Lithania	10	41
		1,074	

these subspecies.

MATERIALS AND METHODS

Sexual variation was not significant, but age variation was evident in *Apodemus agrarius* (Koh, 1983). Juveniles, subadults, and old adults were not used, and 1,074 specimens of young and middle-aged adults from 41 localities in Eurasia, representing 15 subspecies (*chejuensis, coreae, pallescens, manchuricus, pallidior, ningpoensis, insulaemus, tianschancus, ognevi, agrarius, septentrianalis, nikolski, caucasicus, karelicus, and volgensis* (see Table 1 and Fig. 1).

Four external and 27 cranial characters were measured (for the details of measuremnts, see Koh, 1983). Sample statistics such as mean were calculated by subprogram Descriptive of SPSS/pc+ program: discriminant analysis was also performed by subprogram Discriminant. Principal Component Analysis, PCA, and cluster analysis of Unweighted Pair Group Methods of Arithmatic means, UPGMA, were carried out using subprogram Eigen and Sahn of NTSYS/pc program, respectively.

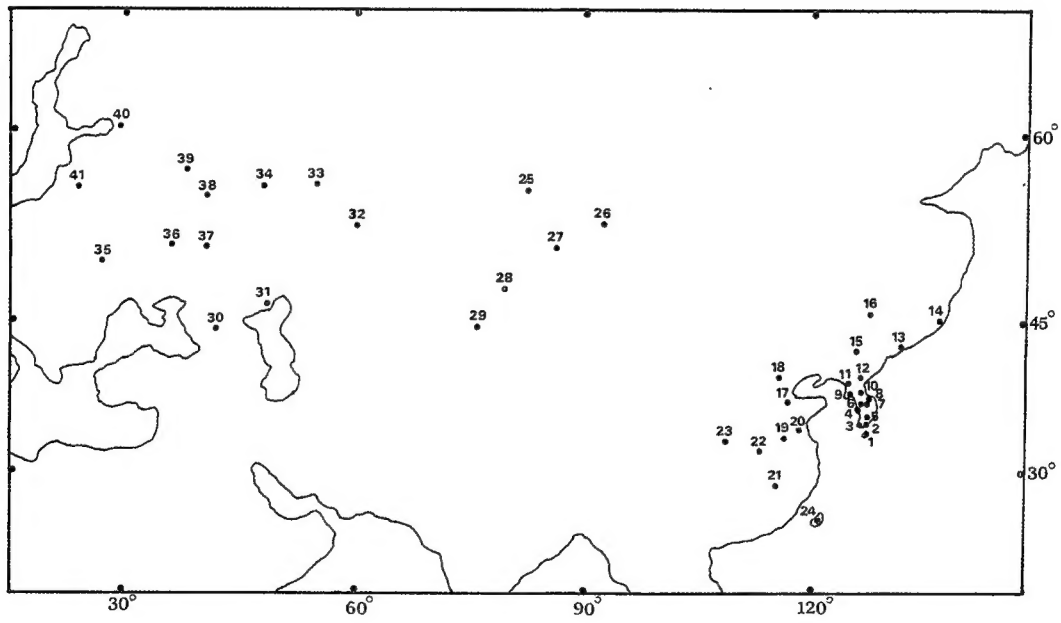

Fig. 1. A map showing 41 OTUs in 15 subspecies of *Apodemus agrarius* from Eurasia. The subspecies name and number of specimens in each OTU are given in Table 1.

RESULTS

Forty one OTUs of 15 subspecies in *A. agrarius* were grouped by the cluster analysis of UPGMA with taxonomic distances, as shown in Fig. 2. Five major subgroups were revealed: (OTUs 1 and 2), (OTUs 3 to 8), (OTUs 9 to 24), (OTU 31), and (OTUs 25 to 30 and OTUs 32 to 41).

Two dimensional configurations of 41 OTUs in *A. agrarius* by PCA are shown in Fig. 3. Factors I, II, and III represented 78, 7, and 5 percents of the variance, respectively (90 percents in total), and principal components I, II, and III expressed as correlations between characters and individual components are shown in Table 2. Two dimensional plottings by discriminant analysis with individual measurements of specimens grouped into 41 OTUs in *A. agrarius* are shown in Fig. 4 (numerals indicate the centroids of OTUs). Functions I, II, and III represented 56, 11, and 8 percents of the variance, respectively (75 percents in total), and functions I, II, and III expressed as correlations between characters and individual functions are given in Table 3. Five major subgroups, as mentioned above, can be recognized mainly based on their size.

In summary, five major subgroups based on their morphometric characters were recognized: I, a largest-size form, specimens from two southern islands in Korea (Chejudo and Wando Islands), subspecies *chejuensis*; II, a large-size form, specimens from six localities in Korea (Jindo Island, Kunsan, Mt. Chirisan, Cheongju, Mt. Weolaksan, and Mt. Taebaeksan), subspecies *coreae* and *pallescens*; III, the other large-size form, specimens from Astrachan in western Russia, subspecies *volgensis*; IV, a medium-size form, specimens from 16 localities in eastern Asia [four localities in North Korea (Haeju, Mt. Kumkangsan, Sineuiju, and Mt. Myohyangsan), ten localities in China (Jirin, Yichun, Sandong, Hopeh, Anhui, n. Jangsu, Kiangsi, Hupeh, Sichuan, and Taiwan), and two localities in eastern Russia (Vladivostok and Ternej)], five subspecies (*coreae, manchuricus, pallidior, ningpoensis,* and *insulaemus*); V, a small-size form, specimens from 16 localities in western Asia and Europe [Kazakhstan (Alma-Ata and Ajagra), Russia (Novosibirsk, Minusinsk, Bijsk, Troick, Birsk, Kazan, Rajan, Bobrov, Nalchik, Komakovo, Kursk, and Petersberg), Lithuania (Trakai), and Ukraine (Vinnica)], seven subspecies (*tianschanicus, ognevi, agrarius, septentrionalis, nikolski, caucasicus,* and *karelicus*).

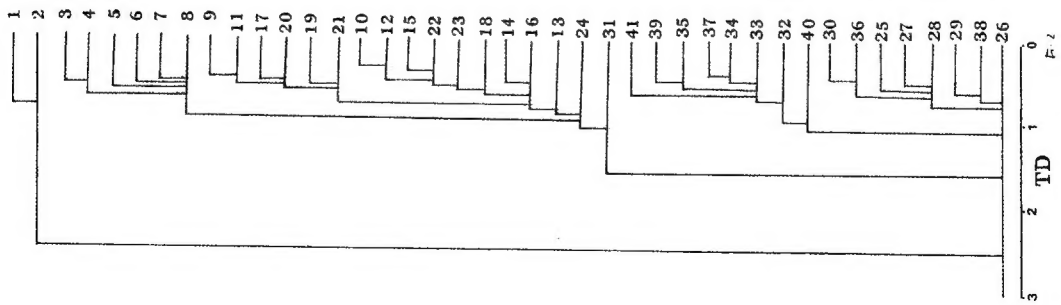

Fig. 2. Grouping of 41 OTUs in 15 subspecies of *Apodemus agrarius* from Europe by cluster analysis of UPGMA with taxonomic distances (TD). The subspecies name and locality of each OTU are given in Table 1.

Table 2. Principal components I, II, and III expressed as correlations between characters and individual components from an analysis with 15 subspecies of striped field mice, *Apodemus agrarius*, from Eurasia.

Characters	Factor I	Factor II	Factor III
1	0.98	0.06	-0.13
2	0.97	0.06	-0.09
3	0.78	0.43	-0.13
4	0.96	0.13	-0.08
5	0.97	-0.07	-0.07
6	0.95	-0.08	-0.04
7	0.95	-0.24	-0.05
8	0.89	-0.22	-0.26
9	0.21	0.62	0.63
10	0.93	0.28	-0.05
11	0.92	0.14	0.04
12	0.89	-0.01	0.07
13	0.90	-0.12	0.25
14	0.88	0.34	-0.22
15	0.94	-0.16	0.16
16	0.90	0.12	-0.13
17	0.89	-0.24	-0.05
18	0.78	-0.10	0.46
19	0.96	-0.01	-0.07
20	0.93	0.22	-0.18
21	0.89	-0.30	0.10
22	0.96	0.14	-0.07
23	0.92	-0.11	0.28
24	0.92	-0.03	-0.15.
25	0.95	0.05	-0.08
26	0.84	-0.21	0.40
27	0.79	0.25	0.33
28	0.85	-0.21	-0.16
29	0.90	-0.28	-0.05
30	0.38	0.67	0.14
31	0.81	-0.25	0.12

DISCUSSION

Boyce (1969) noted that UPGMA represents a distance matrix of random points better than either complete or single linkage, and Rohlf (1970) stated that the relationships between close neighbors are frequently distorted in an ordination, especially one based on PCA. Discriminant ananlysis ordinates two or more *a priori* defined groups as that there is minimum overlap and

Table 3. Discriminant functions I, II, and III expressed as correlations between characters and individual functions from an analysis with 15 subspecies of striped field mice, *Apodemus agrarius*, from Eurasia.

Characters	Function I	Function II	Function III
1	0.53	-0.17	0.60
2	-0.08	-0.31	-0.08
3	-0.08	-0.07	0.34
4	-0.09	0.04	-0.17
5	0.12	-0.04	-0.14
6	-0.02	0.11	0.07
7	0.17	-0.07	-0.22
8	0.46	-0.58	0.43
9	-0.24	0.23	0.15
10	0.04	0.40	-0.24
11	0.12	0.25	0.06
12	0.03	0.01	0.08
13	0.06	0.18	0.13
14	-0.16	0.18	0.62
15	0.12	0.10	-0.07
16	0.09	0.30	-0.02
17	-0.05	-0.17	0.08
18	0.05	0.21	-0.02
19	-0.07	0.01	-0.50
20	0.02	-0.16	0.22
21	-0.05	0.40	-0.57
22	0.07	0.36	-0.14
23	0.22	0.17	0.07
24	0.05	-0.26	0.03
25	-0.14	-0.10	0.13
26	0.15	0.15	-0.18
27	-0.13	0.22	0.04
28	0.10	-0.33	-0.31
29	0.31	-0.08	-0.03
30	-0.45	0.20	0.24
31	0.19	0.11	-0.28

maximum separation among them (Thorpe, 1981), whereas PCA makes no assumption about the existance of grouping among the OTUs (Clifford and Stephenson, 1975). Sneath and Sokal (1973) stated that there are no satisfactory methods for telling whether clustering or ordination is appropriate. In this paper, five major subgroups were revealed by UPGMA cluster analysis (Fig. 2), PCA (Fig. 3), and discriminant analysis (Fig. 4) with 31 morphometric characters of 15 subspecies of *Apodemus agrarius*: I, a largest-size form (OTUs 1 and 2); II, a large-size form (OTUs 3 to 8);

III, the other large-size form (OTU 31); IV, a medium-size form (OTUs 9 to 24); and V, a small-size form (OTUs 25 to 30 and OTUs 32 to 41).

Ellerman and Morrison-Scott (1951) recognized ten subspecies from 18 named subspecies of *Apodemus agrarius* (*agrarius* including *albostiratus, maculatus, rubens,* and *nikolski*; *ningpoensis* including *harti*; *manchuricus* including *coreae* and *gloveri*; *pallidior*; *ognevi*; *septentrionalis* including *karelicus*; *tianschanicus*; *insulaemus*; *caucasicus*; and *volgensis*). Corbet (1978) noted that most of the named forms of *A. agrairus* had been separated on the basis of slight differences in colour or mean size: he summarized 13 nominal subspecies from western Asia and Europe into a western subspecies *agrarius*, and nine named subspecies from eastern Asia into an eastern subspecies *ningpoensis*. Wang (1985) noted that the subspecific classification of the striped field mouse, *Apodemus agrarius*, is in great confusion even in China, and Wilson and Reeder (1993) listed 22 subspecies in *A. agrarius*.

In Korea, Johnson and Jones (1955) stated that *A. agrarius chejuensis* subsp. n. from Chejudo Island is larger, both externally and cranially, than any other described subspecies of *A. agrairus*. Jones and Johnson (1965) reported four subspecies of *Apodemus agrarius*: *chejuensis* in Chejudo Island, *pallescens* in the coastal lowlands of southern and southwestern Korea, *coreae* throughout the major portion of the peninsula, and *manchuricus* in the extreme northern part, although Corbet (1978) stated that the insular form from Chejudo Island (subspecies *chejuensis*) is rather large but is not very distinctive. Koh (1987) and Koh et al. (1998) concluded from morphometric analyses with specimens of striped field mouse from Korea that *A. agrarius chejuensis* (a large-size form) from Chejudo and Wando Islands is different from *A. agrarius coreae* (a small-size form) in other parts of Korea. In this paper (see Table 1 and Figs. 2, 3, and 4), specimens of subspecies *chejuensis* (subgroup I, a largest-size form) differed from those of other 14 subspecies (subgroup II, a large-size form; subgroup III, the other large-size form; subgroup IV, a medium-size form; and subgroup V, a small-size form), and it is concluded that subspecies *chejuensis* is the largest-size form, as suggested by Johnson and Jones (1955).

Johnson and Jones (1955) noted that *Apodemus agrarius pallescens* subsp. n. is slightly larger in both external and cranial dimensions than subspecies *coreae*. In morphometric analysis with specimens of *A. agrarius* from ten localities in Korea (Koh, 1986), including eight samples from Kunsan, it is concluded that subspecies *pallescens* is the synonym of subspecies *coreae* because these two subspecies are similar. In this paper (see Table 1 and Figs. 2, 3, and 4), it is also concluded that subspecies *pallescens* is the synonym of subspecies *coreae* because of their similarity in morphometric characters.

Thomas (1906) noted that there seems to be no difference between the specimens from Quelpart (Chejudo) and those from the Korean mainland in *Apodemus agrarius*, but Thomas (1908) stated that *A. agrarius* coreae subsp. n. has colour of cinnamon, which differs from *manchuricus* with more or less tawny colour, and Ellermann and Morrison-Scott (1951) noted that subspecies *coreae* is the synonym of subspecies *manchuricus*. Koh (1991) and Koh *et al.* (1997) stated that subspecies *coreae* (a medium-size form) is distinct from five subspecies of *agrarius, manchuricus, ningpoensis, pallidior,* and *insulaemus* (a small-size form) and from *chejuensis* (a large-size form) as well. In this morphometric analyses with 15 subspecies of *A. agrarius*, subspecies *coreae* (subgroup II, a large-size form) differs both from subspecies *chejuensis*

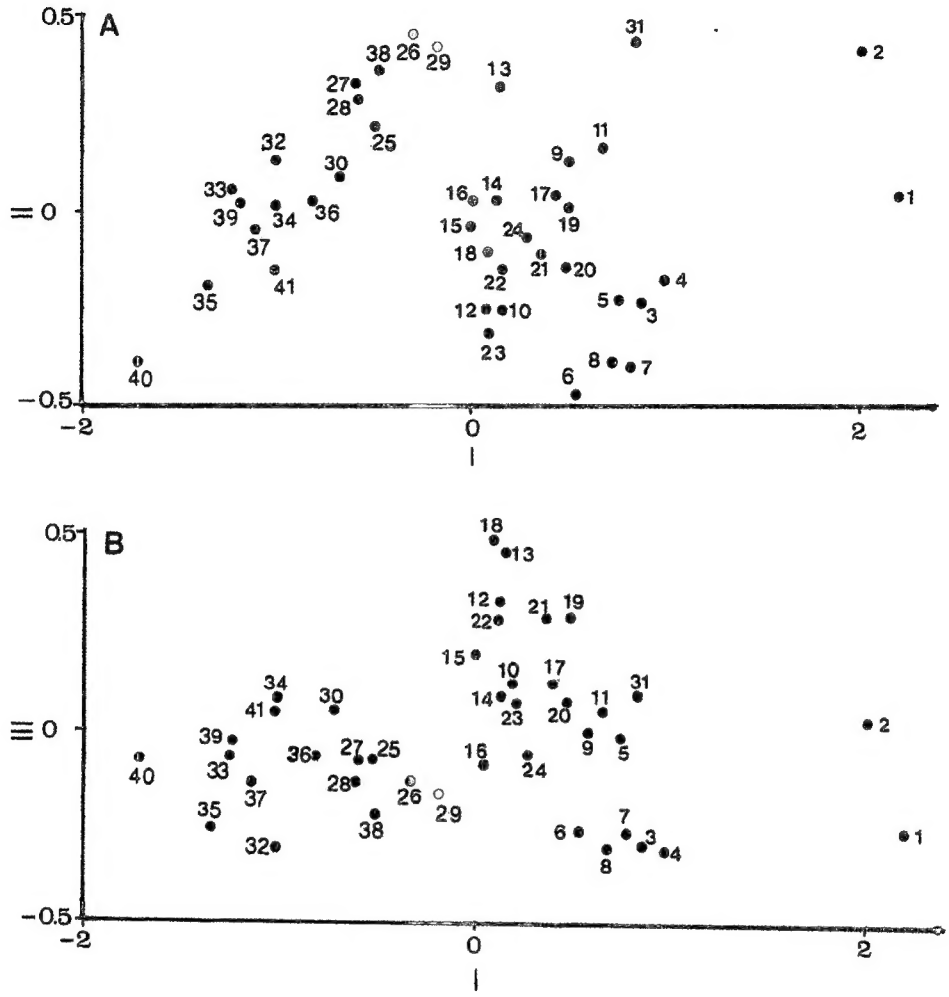

Fig. 3. Projections of 41 OTUs in 15 subspecies of *Apodemus agrarius* from Eurasia by principal component analysis. Numerals indicate OTUs, and the subspecies name and locality of each OTU are given in Table 1. A, OTUs ordinated with factor I vs. factor II. B, OTUs ordinated with factor I vs. factor III.

(subgroup I, a largest-size form) and from other 12 subspecies in Eurasia (subgroup III, the other large-size form; IV, a medium-size form; and V, a small-size form), and it is concluded that subspecies *coreae* from Korea is a distinct subspecies of *A. agrarius*.

Thomas (1906) stated that *Apodemus agrarius manchuricus* of Manchurian forms do not differ from that of Korean forms and that they are not different from subspecies *ningpoensis*. Jones and Johnson (1965) noted that when specimens are available from northern part of Korean peninsula they would expect to find *A. a. manchuricus* in the high mountains of extreme northern Korean peninsula and *A. a. coreae* in the north-central parts. In this paper (see Table 1 and Figs. 2, 3, and 4), specimens from North Korea are similar with specimens from China and eastern Russia to form subgroup IV (subspecies *manchuricus, pallidior, ningpoensis,* and *insulaemus*), indicating

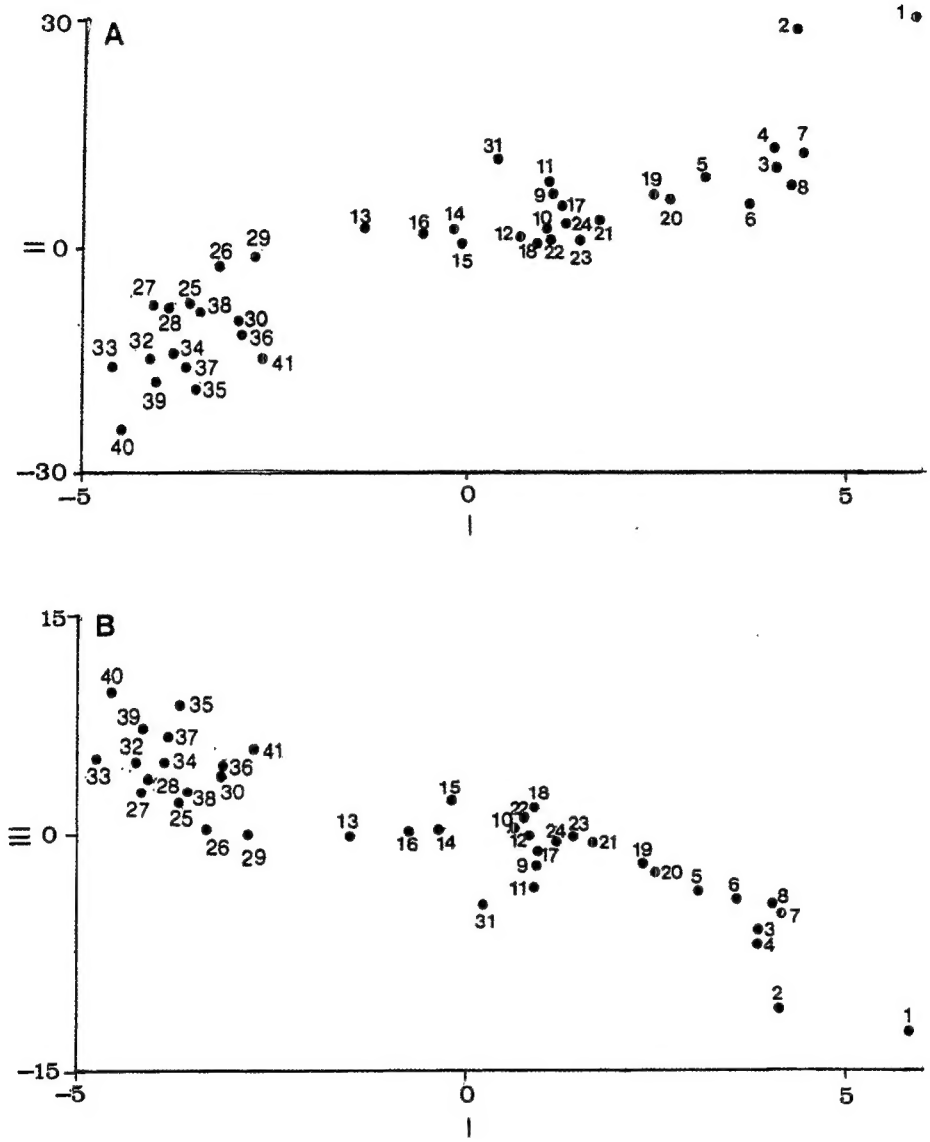

Fig. 4. Plottings of 41 OTUs in 15 subspecies of *Apodemus agrarius* from Eurasia by discriminant analysis. Numerals indicate the centroid of OTUs, and the subspecies name and locality of each OTU are given in Table 1. A, OTUs ordinated with functions I vs. function II. B, OTUs ordinated with function I vs. function III.

that North Korean specimens are the eastern subspecies *ningpoensis* by Corbet (1978), although more samples from North Korea are needed for further analyses.

Thomas (1908) noted that *Apodemus agrarius manchuricus* subsp. n. is slightly larger than subspecies *agrarius*, and Vinogradov and Argiropulo (1941) recognized three subspecies of *A. agrarius* in Russia; *agrarius, karelicus,* and *manchuricus*. Corbet (1978) stated that the western form of subspecies *agrarius* and the eastern form of subspecies *ningpoensis* in *A. agrarius* are not

clearly differentiated. Koh (1991) also noted that 11 specimens of subspecies *agrarius* are not different from those of subspecies *manchuricus, ningpoensis, pallidior,* and *insulaemus* in their morphometric characters, i.e., they formed a small-size form. However, in this paper from morphometric analysis with samples of 15 subspeces of *A. agrarius* (see Table 1 and Figs. 2, 3, and 4), subgroup IV includes four subspecies from China and eastern Russia, and subgroup V consists of seven subspecies from Europe and western Asia, indicating that the designation of two subspecies of eastern and western forms by Corbet (1978) is appropriate.

In China, Thomas (1908) recognized three subspecies of *Apodemus agrarius* mainly based on pelage colour, and stated that *pallidior* subsp. n. is greyish in colour. Tate (1947) noted that three subspecies (*manchuricus, ningpoensis*, and *pallidior* of *A. agrarius* inhabit in China. However, five subspecies of *A. agrarius* are recognized in China (Xia, 1984): *agrarius* from Omin, Tacheong, and northern Xinjiang; *manchuricus*, northeastern China and eastern Inner Mongolia; *pallidior*, northern China, eastern part of northwestern China, Sichuan, and northern Jiangsu; *ningpoensis*, middle and lower part of Yangtze Valley, Guizhou, and northern Fujian; and *insulaemus*, Taiwan. Based on the comparison of black dorsal stripe and colour of their dorsal hair, Liu *et al.* (1991) noted that subspecies *pallidior* from northern part of its distribution is the synonym of subspecies manchuricus and that *pallidior* from southern part of its distribution is the synonym of *ningpoensis*.

Jones and Johson (1965) stated that *Apodemus agrarius manchuricus* is smaller than subspecies *coreae,* and Corbet (1978) noted that insular forms of subspecies *insulaemus* from Taiwan is rather large but are not very distinctive. Based on morphometric characters, Koh (1991) stated that a small-size form is composed of five subspecies (*agrarius, manchuricus, pallidior, ningpoensis*, and *insulaemus*), whereas a medium-size form consisted of subspecies *coreae*. Koh *et al.* (1997) concluded from their morphometric analysis that specimens of four subspecies (*manchuricus, pallidior, ningpoensis,* and *insulaemus*) of *A. agrarius* from China are similar with one another, and that these four subspecies can be reclassified into the subspecies *ningpoensis,* as noted by Corbet (1978). In this paper (Table 1 and Figs. 2, 3, and 4), subspecies *manchuricus, pallidior, ningpoensis,* and *insulaemus* formed a subgroup IV, and it is concluded that the eastern subspecies *ningpoensis* by Corbet (1978) is a distinct subspecies of *A. agrarius* and that it includes subspecies *manchuricus, pallidior,* and *insulaemus.*

Ognev (1924) noted that *Apodemus agrarius ognevi* is smaller than subspecies *manchuricus,* but it is larger than *agrarius.* and that *septentrionalis* subsp. n. is smaller than subspecies *agrarius, ognevi*, and *manchuricus.* Migulin (1927) noted that subspecies *nikolski* subsp. n. is larger than *septentrionalis.* Dukelskaya (1928) noted that subspecies *caucasicus* is larger than *agrarius,* but smaller than *ognevi.* Ognev (1940) stated that subspecies *tianshanicus* subsp. n. is larger than subspecies *agrarius.* Vinogradov and Argiropulo (1941) noted that subspecies *caucasicus* and *ognevi* are the synonym of subspecies *agrarius,* and that among three subspecies of *A. agrarius* in Russia subspecies *agrarius* is larger than subspecies *karelicus,* but it is smaller than *manchuricus.* Ellermann and Morison-Scott (1951) statd that subspecies *nikolski* is the synonym of subspecies *agrarius*, and that subspecies *karelicus* is the synonym of subspecies *septentrianalis*. In this result (see Table 1 and Figs. 2, 3, and 4), subgroup V consisted of seven subspecies of *A. agrarius* and it is confirmed that the western subspecies *agrarius* by Corbet (1978) is composed of subspecies

tianschanicus, ognevi, agrarius, septentrionalis, nikolski, caucasicus, and *karelicus*.

Ognev (1940) stated that *A. agarius volgensis* subsp. n. is larger than subspecies *tianschanicus*. Mayr and Ashlock (1991) defined a polytopic subspecies as similar or phenotypically indistinguishable subspecies in geographically separated areas. In this result (see Table 1 and Figs. 2, 3, and 4), it is revealed that subspecies *volgensis* (subgroup III, the other large-size form) from western Russia is different from the westen Eurasian form of seven subspecies (subgroup V, a small-size form) including subspecies *tianschanicus*, and that it is more or less similar with subspecies *coreae* from Korea (subgroup II, a large-size form), indicating that it is an example of polytopic subspecies, and it is concluded that subspecies *volgensis* is a distinct subspecies, which differs from the eastern subspecies *agrarius*.

Developments in the areas of molecular, cyto-, and numerical taxonomy are enormous (Quicke, 1993) and there has been a conflict between molecular biologists and morphologists about the merits of their data (Ferguson, 1980). But modern molecular techniques have not yet pushed comparative morphology into the shadows (Patterson, 1987). It was advocated that a classification should be the product of all available characters distributed as widely and evenly as possible over the organisms studied (Mayr and Ashlock, 1991; Huelsenbeck *et al.*, 1996). Zhao and Lu (1986) analyzed biochemical characters of samples in two subspecies of striped field mouse from Sandong, Jiangsu, and Anhui provinces and concluded that *A. agraius pallidior* from Sandong is distinct from *A. agrarius ningpoensis* from Jiangsu and Anhui provinces. In the analyses of mtDNA restriction fragment patterns with two subspecies of *Apodemus agrarius* from Korea, subspecies *chejuensis* differed from subspecies *coreae* (Koh and Yoo, 1992). In mtDNA analyses of two subspecies of *A. agrarius* from China and Korea, subspecies *pallidior* from China and *coreae* from Korea are different in their mtDNA genotypes with each other (Wang and Koh, 1997), indicating that these three subspecies are different in their mtDNA genotyes.

However, Kral (1970) also noted that karyotype of *A. agrarius ognevi* and *A. agrairus manchuricus* from Russia is 2n = 48 (40 acrocentrics and 8 meta-submetacentric chromosomes). Koh (1982, 1987) noted that the karyotype of *A. agrarius coreae* and *A. agrarius chejuensis* is the same, i.e., diploid number of 48 (38 acrocentric autosomes, four pairs of small metacentric autosomes, large acrocentric X chromosome, and small acrocentric Y chromosome). Wang *et al.* (1993) reported that karyotype of *A. agrarius pallidior* is eight metacentric and 38 telocentric autosomes with large telocentric X and small telocentic Y chromosomes, indicating that those five subspecies of *A. agrarius* are similar with one another in their karyotypes.

In summary, it is concluded that 15 subspecies of *Apodemus agrarius* from Eurasia can be classified into five subspecies in the comparison of morphometric characters: subspecies *chejuensis; coreae* including *pallescence; ningpoensis* including *manchuricus, pallidior, insulaemus; volgensis; and agrarius* including *tianschanicus, ognevi, septentrionalis, nikolski, caucasicus*, and *karelicus*. However, morphometric analyses with specimens of other seven subspecies (*albostriatus, maculatus, rubens, kahmanni, henrici, gloveri*, and *harti*) from Eurasia are necessary for the complete reclassification of this species: Ellermann and Morrison-Scott (1951) noted that subspecies *albostriatus, maculatus*, and *rubens* are the synonym of subspecies *agrarius*, that *harti* is the synonym of *ningpoensis*, and that *gloveri* is the synonym of *manchuricus*. Furthermore, Corbet (1978) stated that subspecies *henrici* and *kahmanni* are the

synonym of subspecies *agrarius*.

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요 약

유라시아에 서식하는 등줄쥐 (*Apodemus agrarius* Pallas) 15 아종의 표본들의 31개 형태 형질의 분석을, 이들 아종들의 분류학적 위치를 검토하기 위하여, 수행하였다. 등줄쥐의 5개 주요 아군 (subgroup)이 나타났다: I, 가장 큰 형, 한국 2개 섬 지역의 표본, 아종 *chejuensis*; II, 큰 형, 한국 6개 다른 지역의 표본, 아종 *agrarius*와 *pallescens*; III, 다른 큰 형, 서부 러시아 Astrachan의 표본, 아종 *volgensis*; IV, 중간 크기 형, 동부 아시아의 16개 지역 (북한, 중국, 동부 러시아)의 표본, 아종 *coreae*, *manchuricus*, *pallidior*, *ningpoensis*와 *insulaemus*); V, 작은 형, 서부 아시아와 유럽의 16개 지역 (카자스탄, 러시아, 리튜아니아, 우크라이나)의 표본, 아종 *tianschancus*, *ognevi*, *agrarius*, *septentrianalis*, *nikolski*, *caucasicus*, and *karelicus*). 본 형태 형질의 분석의 결과로 내린 결론은 다음과 같다: 아종 *chejuensis*는 Johnson과 Jones (1955)이 밝힌 대로 가장 큰 형이다: 아종 *pallescens*는, 고 (1986)가 제안한 바대로, 아종 *coreae*의 동종이명이다: 한국의 아종 *coreae*는 큰 형으로 유라시아에 서식하는 다른 12 아종과 다르다: Corbet (1978)가 제안한 동부 아종인 *ningpoensis*는 중간 크기의 형을 보이는 중국과 동부 러시아의 표본들 (아종 *manchuricus*, *pallidior*, *ningpoensis*와 *insulaemus*)이며, 북한의 표본들도 포함된다: 작은 형인 서부 아시아와 유럽의 표본들 (아종 *tianschanicus*, *ognevi*, *agrarius*, *septentrionalis*, *nikolski*, *caucasicus*, and *karelicus*)은 Corbet (1978)가 제안한 서부 아종인 *agrarius*이다: 또 다른 큰 형인 서부 러시아의 아종 *volgensis*는 서부 아종인 *agrarius*와 다른 독특한 아종이다. 그러므로, 등줄쥐의 15아종은 5아종 (*chejuensis*, *coreae*, *ningpoensis*, *agrarius*, and *volgensis*)으로 재분류할 수가 있다고 판단되지만, 이 종의 완전한 분류를 위해서는 나머지 7개 아종 (*albostriatus*, *maculatus*, *rubens*, *kahmanni*, *henrici*, *gloveri*, and *harti*)의 표본들의 측정과 분석이 필요하다.